BP Products North America Inc.
2815 Indianapolis Blvd.
P.O. Box 710
Whiting, IN 46394-0710
USA

July 5, 2011

Mr. Paul Higginbotham, Chief
Permits Branch
Office of Water Quality
Indiana Department of Environmental Management
100 North Senate Avenue
Indianapolis, Indiana 46204

Re: Revised 316(a) Thermal Variance Demonstration Study Plan for NPDES Permit No. IN0000108, BP Products North America, Whiting, Indiana Lake County

Dear Mr. Higginbotham,

Please find attached the revised Study Plan for a 316(a) thermal variance demonstration as Phase 2 of our efforts to meet the thermal effluent requirements in BP Whiting Refinery NPDES permit (No. IN0000108). This update is in response to your June 10, 2011 comments and subsequent follow-up discussion on June 20, 2011 providing clarifications to these comments. The following summarizes our responses to your letter dated June 10, 2011. (IDEM comments are not repeated here, rather they are referenced by Section numbers):

Comments on Introduction (Section 1):

BP Response: Per our discussion, the wind and current data will be obtained from local weather station and NOAA buoy and documented to verify the ambient conditions during the sampling events.

Comments on Sampling Locations (Section 2.1):

BP Response: The sampling locations for Sites 2 and 3 have been moved according to IDEM suggestions. The sampling Site 9 is added as requested. The GPS coordinates will be recorded for sampling methods as suggested by IDEM. The boat will be anchored if needed during the GPS data and in-situ water quality data collection, based on professional judgment.

Comments on Sampling Methods (Section 2.2):

BP Response: IDEM's suggestions on sampling methods have been incorporated in the revised study plan. Sampling will be avoided within one to two days of sustained onshore winds and heavy wave action to allow for stabilization.

Based on further consultation with IDNR and IDEM, One or two of each species will be preserved to serve as voucher specimens for the field study project. If the specimens are too large to preserve, a photo of key characteristics for the species will be taken, including overall profile of fish, the site of collection, date, and scale. Whenever there is a question or uncertainty of identification at any sampling locations during the sampling events, a voucher will be kept or digital image(s) will be taken with key characteristics highlighted so that the uncertain or unknown individual can be later confirmed. If necessary, more than one image may be taken to record key taxonomic feature(s) (highlighted characteristics) so that confident identification can be made from the picture. IDEM will provide guidance on how long the vouched specimens will be retained.

Comments on Habitat (Section 2.3 and 3.3):

BP Response: BP agreed that the habitat will be assessed as suggested by IDEM.

Comments on Physicochemical Measurements (Section 2.4):

BP Response: BP agreed that the physicochemical parameters will be measured at suggested locations for the three fishing gears. The collected data will be geo-referenced and provided in excel format.

Comments on Data Analysis and Report Preparation (Section 3):

BP Response: BP agreed that the fish data will be compiled as suggested by IDEM. The fifteen measure/metrics identified by IDEM will be calculated on fish data. No IBIs will be calculated and compared for this Study.

Comments on Representative Important Species (Section 3.2):

BP Response: As discussed during our conference call, the brief life history review will be conducted using recent research. The review will focus on thermal tolerance of RIS species.

Comments on Photo Imaging of field study:

BP Response: As discussed during our conference call, only the representative field photos will be taken to document field work.

In addition, BP proposes to submit the completed data analysis and demonstration report by approximately July 31, 2012. According to NPDES permit (Page 52 0f 53), If the draft 316(a) study plan has not been approved by IDEM within thirty months of the effective date of the permit, the permittee shall submit any 316(a) demonstration/variance application twenty-four months subsequent to IDEM approval of the study plan. BP plans to conduct the field study in 2011 and complete data analysis and demonstration report by approximately end of July 2012. This is well within the two years given by IDEM from the date of your approval which is anticipated in July 2011.

We appreciate your assistance on this compliance effort and look forward to your approval of the revised study plan so we can remain on schedule. Should you have any additional questions, please feel free to contact Rose Herrera at 219-473-3393 or email at Rosalie.Herrera@bp.com.

Sincerely

Linda Wilson

Linda Wilson
Environmental Manager

CC: Steve Roush, IDEM
Jim Stahl, IDEM
Rose Herrera, BP
Pete Beronio, BP
Ben B. Zhang, AECOM
Greg Seegert, EA

Attachment: Revised Study Plan for 316(a) Thermal Variance Demonstration

BCC: File documentum 4K14 Thermal Study Phase II 316 (a) Demonstration 2011

Proposed Study Plan

for a 316(a) Thermal Variance Demonstration near the BP Whiting Refinery

EA Project 14429.05

Prepared for:
AECOM Technical Services, Inc.
27755 Diehl Road, Suite 100
Warrenville, IL 60555

Prepared by:
EA Engineering, Science, and Technology, Inc.
444 Lake Cook Road, Suite 18
Deerfield, IL 60015

July 1, 2011

1. INTRODUCTION

The proposed study plan was submitted to Indiana Department of Environmental Management (IDEM) on May 27, 2011. The plan has been revised based on IDEM's comments dated June 10, 2011.

The test for a 316(a) demonstration is whether alternative thermal effluent limitations will assure the protection and propagation of a balanced indigenous community (BIC) outside any established mixing zone. The mixing zone at the BP Whiting Refinery has been established as a 1000ft arc extending outward from Outfall 002. Thus, the objective of this study will be to determine whether a BIC exists outside the 1000' arc. Summer is the period when temperature is expected to be most limiting to Lake Michigan fishes so this field effort will concentrate on that period, as suggested by Indiana Department of Environmental Management (IDEM). However, because it is possible that some avoidance of the thermal plume during the summer may occur, one sampling event is planned to occur in the fall to determine whether the distributional patterns observed during the summer persist.

Based on a recent thermal modeling study of the refinery's thermal plume (AECOM 2011), IDEM's comments (dated August 13, 2010) on the original study plan, and a teleconference call with IDEM staff on April 8, 2011, this study plan will focus on sampling aquatic vertebrates. Thermal loadings from the refinery are fairly constant, thus the magnitude, aerial extent, and orientation of the plume is mainly the result of lake currents and wind speed and direction. The thermal plume study result showed that under most likely prevailing conditions, the plume either migrates east, then northeast of the plant, staying close to shore because of northwesterly winds, or, when winds are from the south-southeast, the plume gets blown offshore and moves either north or northwest (see Figure 1). Other wind and current scenarios are possible, but these two conditions are predominant and thus present the most likely scenario for effects to aquatic organisms near the refinery. Thus, the study described herein was designed to assess these predominant scenarios. Under the scenario where the plume migrates eastward along the south shore of Lake Michigan, electrofishing can be used to assess the nearshore component of the plume where depths are less than 10 feet, but when winds are from the south and the plume migrates offshore, electrofishing will not be effective. Therefore, we include gill netting and bottom trawling to assess off-shore conditions where depths exceed 10 feet and electrofishing to assess near-shore conditions.

It should be noted, however, that though the sampling locations described in the next section will be established to assess potential worst case conditions, these locations will be fixed for consistency among the sampling events. The size and location of the plume varies, dependent on wind and current conditions. As a result, on a given date, some "impact" locations may be in the plume, while others may not. However, the locations

chosen will reflect the predominant wind/current directions and thus, on average, be an accurate reflection of conditions outside the 1000 ft arc during the period when conditions are most limiting. The wind and current directions will be documented based on data from adjacent weather station and NOAA buoy after each sampling event.
The following sections describe the field sampling locations and methods, and technical approach for data analysis and demonstration.

2. METHODS

2.1 SAMPLING LOCATIONS

All sampling locations, along with most likely plumes, are depicted on Figure 1. The beginning and end of each electrofishing location will be identified with GPS coordinates. Similarly, GPS coordinates will be established at the midpoint of each gill net and trawl location.

Electrofishing (EF)

- Zone 1 – This zone will start at the edge of the 1000 ft arc east of the discharge and will extend east along the shore for 1000m and will be sampled as a T-Zone.
- Zone 2 – This zone will be 500m long and will be located in the small bay west of the refinery but east of Whiting Park. This will be a control location.
- Zone 3 –This zone will be 500m long and will be located just to the west of Whiting Park. It will also be a control location. The sampling will be conducted when there isno swimmer present.
- Zone 4 – If the nearshore area remains relatively shallow (i.e., <10' deep), a location will be sampled to the northeast of Zone 1. Its exact position will be determined in the field but it will not extend beyond (eastward) gillnet Location 4 and may begin within 50m of where EF Zone 1 ends. If a suitable habitat of 1000m long can be found, this zone will also be sampled as a T-Zone.

Gill Netting and Trawling

Eight locations will be established for both gill netting and trawling. Five potential impact sites and three control locations as follows:

- Location 1 – This location will be centered in the small bay to the east of the discharge. This location should be under the influence of the plume under most or all wind/current conditions.
- Location 2 – This location will be about 500m offshore, north, northeast of the discharge in 15-17ft of water. It will be within the +9 degree temperature zone and just outside of the 1000 ft arc, as shown in Figure 1.

- Location 3 – This location will be located about 900 m north of the discharge in 20-25ft of water. Depending on wind and current conditions, this location usually will be influenced by the plume whenever the plume migrates offshore but the Delta Ts will be low (typically <3F).
- Location 4 – This location will be 1200-1400m northeast of the discharge but its centerpoint will be only about 150m from shore. The net will be set perpendicular to shore with the depth at the center point expected to be about 16-20ft. This location will be influenced by the plume whenever the wind is from the north or northwest.
- Location 5 – This location will be along the southeast shore about 1000m to the NE of Location 4. Like Location 4, Location 5 will be centered about 150m from shore but because of a steeper slope, the depth at this point will likely be 20-25ft. The net will be set perpendicular to shore. This location will also be influenced by the plume when the wind is from the north or northwest.
- Location 6 – This location will be an offshore control location and will be situated about 1700-2000m north of the discharge in 24-28ft of water.
- Locations 7 and 8 – These will serve as near-shore control locations to compare with in-plume Locations 4 and 5. Location 7 will be about 300-400m offshore from EF Zone 2 in 10-15ft of water. It may be moved slightly further offshore depending on depth and habitat. The net will be set perpendicular to shore. Location 8 will be about 600-700m offshore from EF Zone 3 in 15-20ft of water. This net will also be set perpendicular to shore.
- Location 9– as required by IDEM, this location is added to be within the +18 degree temperature zone east from the outfall as shown in Figure 1. This location will be 120m north by northwest of Location 1 and just outside of the 1000 ft arc.

2.2 SAMPLING METHODS

One or two of each species will be preserved to serve as voucher specimens for the field study. IDEM will provide guidance on how long the vouched specimens need to be retained. If the specimens are too large to preserve, a photo of key characteristics for the species will be taken, including overall profile of fish, the site of collection, date, and scale. Whenever there is a question or uncertainty of identification at any sampling locations during the sampling events, a voucher will be kept or digital image(s) will be taken with key characteristics highlighted so that the uncertain or unknown individual can be later confirmed. If necessary, more than one image may be taken to record key taxonomic feature(s) (highlighted characteristics) so that confident identification can be made from the picture.

The boat will be anchored if needed during the GPS data and in-situ water quality data collection, based on professional judgment.

2.2.1 Electrofishing

Electrofishing will be done from an 18' boat with two extendable booms and a 5000-6000 watt generator. Pulsed DC output will be controlled by a Smith Root VVP15B control box. Outputs will be optimized to Lake Michigan conditions. The crew will consist of a boat driver and two people dipping fish with a 3/16" mesh, long-handled dip net. EF Zone 1 will be a 1000m long T-zone as described by Emery and Thomas (2003). For this methodology, the fish collected from each 100m sub-zone will be kept and recorded separately, yielding six 500m zones within Zone 1. If possible, EF Zone 4 will also be sampled following the T-Zone methodology. All other zones will be standard 500m zones since they are control zones and outside the thermal impacts.

For electrofishing Zones 1 and 4, GPS coordinates are to be collected at every 100m point where the physicochemical measures are taken at the starting and ending point of each 100m zone of the T-Zone. For electrofishing Zones 2 and 3, the GPS coordinates are to be collected at the starting, mid-point, and ending point of each zone. Sampling will be conducted when wave action is 0.6m (about 2ft) or less because waves greater than 0.6 meters prevent effective sampling especially at nearshore Great Lakes sites. The weather and wave condition will be monitored before the each sampling event starts.

If winds have a westerly component, zones will be sampled from the west to the east. If winds have an easterly component, the zones will be sampled from the east to the west. This will allow the boat and stunned fish to move with the shoreline currents and maximize the capture. After periods of sustained onshore winds and heavy wave action, sampling will be avoided to allow for stabilization. If the wave condition changes during the sampling event, the sampling will continue until it is completed or conditions cause health and safety concerns. The wave condition change during a sampling event will be documented.

During each sample event, all fish will be counted and identified. Sportfish and large non-game fish (e.g., common carp, various suckers) will be weighed and measured individually, up to 20 individuals per zone, per event. If more than 20 individuals are collected, a representative subsample of 20 fish will be processed individually. Remaining large fish and all small forage species (e.g., minnows, gobies, alewife) will be counted and batch weighed, by species. Except for specimens that cannot be identified in the field, the fish collected will be released after processing.

For all electrofishing (Zones 1, 2, 3, and 4), fish data will be recorded for each 100m electrofishing zone as well as seconds fished, pulse rate, voltage used, and amperage setting. All fish greater than or equal to 20mm will be sorted by species and for each species, the following data will be recorded:

- IDEM_TAXON-RID
- Total number of individuals

- Maximum and minimum total length (mm)
- Total weight (grams)
- Number of individuals with deformities
- Eroded fins, lesions, tumors or multiple anomalies

To reduce the risk of capturing the same specimens in the next 100m electrofishing zone, fish will be placed in holding pens or released at least 200m away from the next 100m zone.

The electrofishing activities will be logged by representatively taking photos, including bow with netters, anodes in water, processing of fish, holding pens, etc.

2.2.2 Trawling

A 16' bottom trawl with ¼-inch cod end will be used at Locations 1-9. Three, 5-min trawls will be made at each location during each sampling trip. Fish collected will be processed using a similar approach as described for electrofishing. For trawling site, GPS coordinates will be collected to identify the location and extent of the sampling site.

For each 5-minute trawl, all fish greater than or equal to 20mm will be sorted by species and for each species, the following data will be recorded:

- IDEM_TAXON-RID
- Total number of individuals
- Maximum and minimum total length (mm)
- Total weight (grams)
- Number of individuals with deformities
- Eroded fins, lesions, tumors or multiple anomalies

To reduce the risk of capturing the same specimens in the next trawl, fish will be placed in holding pens and released after the third five minute trawl.

Trawling activities will be documented by representatively taking photos, including trawling in process and fish processing.

2.2.3 Gill Netting

Gill netting will be done at Locations 1-9. Each net will be 300' long with 6 panels with the following mesh sizes (bar mesh): ½", 1", 1½", 2", 2½", and 3". The nets will be sinking nets and they will be deployed on the bottom. Each net will be set, checked the next day, reset, then pulled the next day, yielding about two net days at each location. Fish collected will be processed using a similar approach as described for electrofishing. For each gill netting site, GPS coordinates of beginning and ending points will be collected to identify the location and extent of the sampling site.

For each retrieval of the gill net (two days, two set of data), all fish greater than or equal to 20mm will be sorted by species and for each species, the following data will be recorded:

- IDEM_TAXON-RID
- Total number of individuals
- Maximum and minimum total length (mm)
- Total weight (grams)
- Number of individuals with deformities
- Eroded fins, lesions, tumors or multiple anomalies

To reduce the risk of capturing the same specimens in the reset of the gill net, any live fish will be released approximately 1000m from the reset gill net.

Gill netting activities will be documented by representatively taking photos, including deployment and retrieval of gill nets, processing fish, etc.

2.3 HABITAT

As Subcontractor of AECOM, EA Engineering, Science, and Technology, Inc (EA) will evaluate the habitat qualitatively during an initial reconnaissance trip. The purpose will be to ensure that habitats among the four electrofishing zones are as similar as possible in terms of average depth, cover, and substrate. To the extent possible, netting Locations 1, 2, 4, 5, 7, 8, and 9 will be as similar as possible in terms of depth and substrate. Off-shore Location 3 and 6 will be matched to be fairly similar to one another in terms of depth and substrate. Because they need to be near the centerline of the plume, there will be little flexibility in where the nets are set at Locations 1 and 2. Thus, the habitat at these locations may differ somewhat from the other near-shore locations.

During one of the sampling trips, near-shore habitat will be measured using a Qualitative Habitat Evaluation Index (QHEI) developed for Lake Erie (Ohio EPA 2010). Although this method was developed for Lake Erie, it provides an objective way to characterize the shoreline habitats in electrofishing Zones 1-4. We will use this method to establish similarities and differences among zones.

The standard reach length for scoring the L-QHEI is 500 meters of shoreline. Electrofishing Zone 1 and 4 will have two L-QHEI Assessments. One L-QHEI for the first 500m and a second one for the next 500m of 1000m Zones. If Zone 4 cannot reach 1000 due to water depth constraints, the zone will be extended as far as possible in 100m increments for electrofishing purpose with the remaining amount beyond the first 500m L-QHEI scored as unit.

A photo log will be created to document representative types of nearshore habitat, riparian cover, and its extent if present, and submerged and emerged aquatic vegetation within each of the electrofishing zones.

2.4 PHYSICOCHEMICAL MEASUREMENTS

The physicochemical measurements will be conducted for each fishing method, as described below. The data for wind direction, speed, air temperature and lake current direction will be obtained and documented from the adjacent weather station and NOAA buoy.

2.4.1 Measurement during Electrofishing

In-situ water quality measurements of water temperature, dissolved oxygen, specific conductance, Secchi depth, and pH will be collected at subsurface, mid-depth, and bottom at the beginning and end of each electrofishing zone, and at each 100m point of electrofishing zones 1 and 4 in the same position as a GPS coordinates are recorded.

These same parameters will be collected at subsurface, mid-depth, and bottom of the water column, at the starting, mid-point, and end of the zone at electrofishing Zones 2 and 3.

2.4.2 Measurement during Gillnetting and Trawling

Temperature, DO, specific conductance, pH, and Secchi depth will also be measured at the centerpoint of each gillnetting and trawling location. Measurements at the netting/trawling centerpoint locations will be taken 1m below the surface, at the midpoint of the water column and 1m off the bottom. The latter will be most representative of the temperature where the gear was deployed.

The physicochemical measurement activities will be documented by representatively taking field photos. All physiochemical parameter data from all sampling points will be prepared in an Excel format and all physiochemical parameter data from all sampling points will be geo-referenced.

2.5 Fish Sampling Permit

A collecting permit will be obtained from Indian Department of Natural Resources prior to the field work.

2.6 Health and Safety

All field work will follow a Health and Safety Plan (HASP) to be prepared by AECOM. The plan will meet BP's safety policy. The field work will be oversighted by AECOM representative. Conditions on Lake Michigan can change rapidly and unpredictably. Each crew leader will have the authority to abort a trip due to storms or winds. If half or more of the samples are collected before the trip is aborted, sampling will not be rescheduled.

2.7 Quality Assurance and Quality Control

Sampling will be conducted in accordance with EA's Fisheries Procedures Manual (Attachment 1).

3. DATA ANALYSIS AND REPORT PREPARATION

3.1 FISH DATA

Electrofishing data will be provided in Excel format to include: Zone Number (Zone 1 or Zone3), date, time, transect or reach number (i.e., 100m or 400m), IDEM-TAXON_RID, Total number of individuals, Maximum and minimum total length (mm), total weight (grams), number of individuals with DELT (deformities, eroded fins, lesions, and tumors or multiple anomalies), and number of specimens vouchered or photo number (i.e. P005 for photo #5)

Trawling data will be provided in Excel format to include: location number (i.e., Location8 or Location1), date, time, trawl number (i.e. Trawl1 or Trawl3), IDEM-TAXON_RID, Total number of individuals, Maximum and minimum total length (mm), total weight (grams), number of individuals with DELT (deformities, eroded fins, lesions, and tumors or multiple anomalies), and number of specimens vouchered or photo number (i.e. P005 for photo #5)

Gill Netting data will be provided in Excel format to include: location number (i.e., Location4 or Location3), date and time of removal, hours gill net in place, gill net event (i.e. Gillnet1 for first day or Gillnet 2 for second day), IDEM-TAXON_RID, Total number of individuals, Maximum and minimum total length (mm), total weight (grams), number of individuals with DELT (deformities, eroded fins, lesions, and tumors or multiple anomalies), and number of specimens vouchered or photo number (i.e. P005 for photo #5)

All field data sheets will be scanned into PDF format after completed and signed by project manager or the data manager.

To assess possible impacts caused by the BP thermal discharge, catch data will be statistically compared among locations within the plume and the various control locations. Measures or metrics (Simon and Stewart 2006) that will be compared among zones or locations include:

1. Species richness
2. Number of Centrarchid species
3. Percent individuals as obligate Great Lakes species
4. Number of lake habitat species
5. Percent individual as intolerant species
6. Percent individuals as tolerant species
7. Percent individuals as detritivore species
8. Percent individuals as insectivore species

9. Percent individuals as carnivore species
10. Percent individuals as exotic and non-native species
11. Number of individuals
12. Percent individuals as phytophils
13. Percent individuals as DELT anomalies
14. Number of individuals which are Representative Important Species (RIS)
15. Relative Weight (W_r) and/or Condition (K)

IBI will not be calculated on fish data.

3.2 Representative Important Species

For each RIS, a brief life history review will be prepared using recent research. These reviews will describe the abundance of each species in this area, its position in the food web, and any known seasonal changes in abundance and distribution. In particular, we will review the thermal endpoints for each RIS. Endpoints will include upper lethal, avoidance, and preferred temperatures. These endpoints will be compared against actual or predicted temperatures for the BP plume. If avoidance is observed, the study will discuss the area actually or potentially from which each species is excluded and the period of time avoidance occurs or could reasonably be expected to occur.

Based on input from Mr. Brian Breidert at Indiana DNR, four potential RIS species are: perch, smallmouth bass, spottail shiners, and alewife. Final RIS will be selected after data collection is complete. The list of RIS will be sent to IDEM and Mr. Brian Breidert at Indiana DNR for review.

For each RIS, we will attempt to determine to what extent, if any, the BP thermal plume affects its abundance or distribution and to what extent each RIS may be limited, if at all, by either the magnitude of the plume (i.e., its maximum temperature) or its aerial extent.

3.3 HABITAT

The Lake Erie QHEI provides scores for five metrics: substrate, cover, shoreline morphology, riparian zone and bank erosion, and aquatic vegetation. The zones will be compared and contrasted for each of these metrics. The details for scores calculations will be provided in an Excel format.

3.4 REPORT PREPARATION

The 316(b) variance demonstration report will integrate the above-described sections into a 316(a) Type III demonstration. This demonstration will consider both "absence of prior appreciable harm" as in a Type I demonstration and the predictive approach for RIS as used in a Type II demonstration (USEPA 1974). The fish data will be compared with historical data for the area, if available, to assess appreciable harm. If no historical data are available, prior appreciable harm will be assessed based on expectations for this area as determined by results from nearby areas and taking into account data from the reference areas included as part of this study. The report will address whether the BIC exists in the receiving water of BP thermal discharge by comparing the fish data from the sites within plume with the reference sites. In the event that a BIC is not present, the report will consider to what extent, if any, the BP plume contributes to the absence of balance and whether the lack of balance is due to other factors.

3.5 PROPOSED SCHEDULE

Sampling will be scheduled in July, August or September, and October, weather permitting. The field crew will attempt to use all three gears during the same week. However, electrofishing is limited by weather conditions so it may take place in a different week. Table 1 presents the proposed schedule for the implementation of the study plans. The proposed schedule will be adjusted based on the date of plan approval by IDEM, weather conditions or other conditions out of project team's control.

Table 1. Proposed Schedule

Milestones	Estimate Date or Periods
Final Study Plan Submitted to IDEM	07/05/2011
IDEM Approval of Study Plan	07/12/2011
IDNR Permit	07/8/2011
Field Preparation	07/12-07/15/2011
1st Sampling Event*	07/18-07/31/2011
2nd Sampling Event*	08/01-09/15/2011
3rd Sampling Event*	10/03-10/15/2011
Data Analysis	TBD
Draft Report for BP review	TBD
Final Study Report for submittal to IDEM	TBD

*2-3 days per sampling event, weather permitting

4. REFERENCES

AECOM. 2011. BP Whiting Refinery Thermal Plume Study, BP Products North America, Inc. Report prepared for BP Products North America, Inc. Whiting Refinery by AECOM, Warrenville, IL. February 2011.

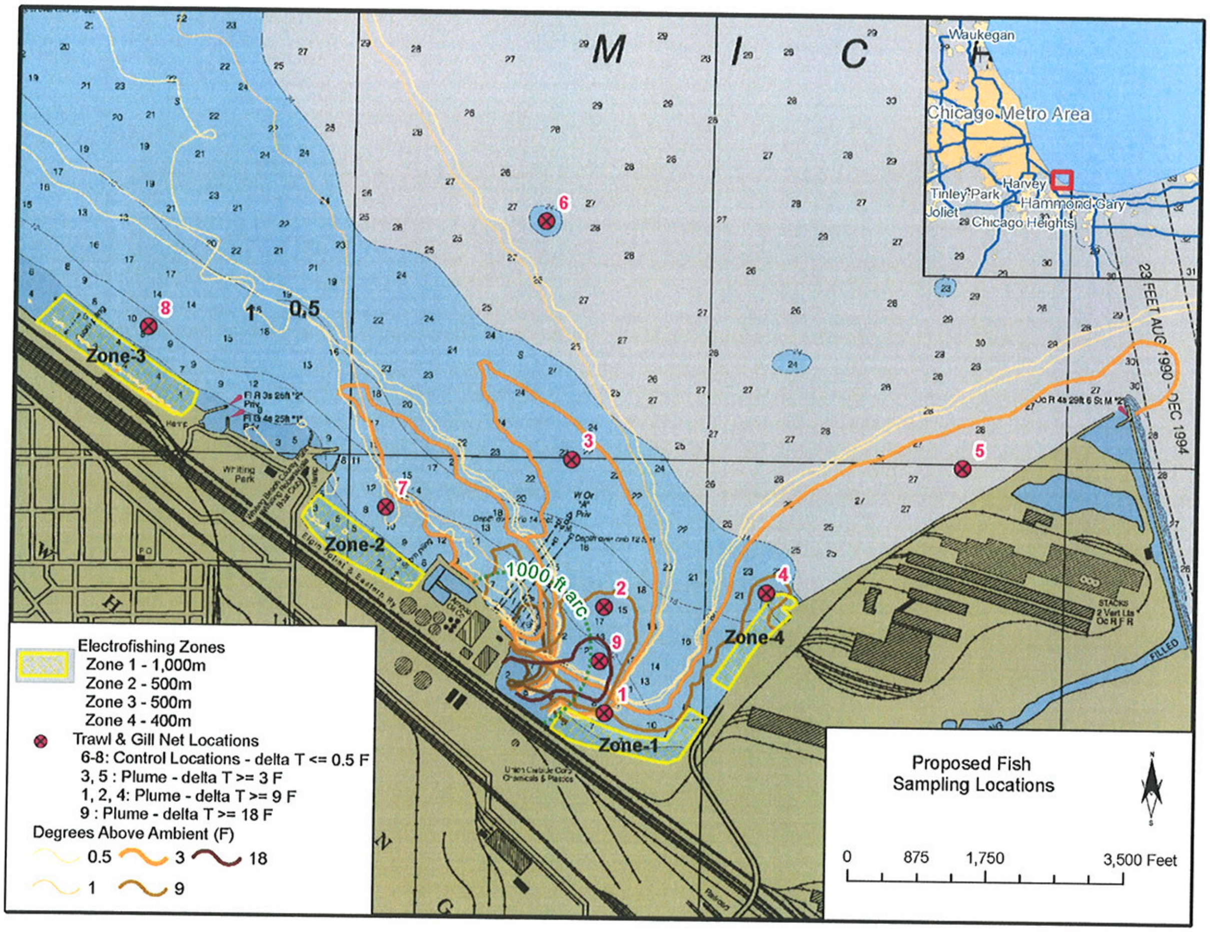
Emery, E. and J. Thomas. 2003. A method for assessing outfall effects on great river fish populations: the traveling zone approach. pp 157-164 in Simon (ed). Biological Response Signatures. CRC Press. Boca Raton, FL.

Ohio EPA. 2010. Methods of Assessing Habitat in Lake Erie Shoreline Waters Using the Qualitative Habitat Evaluation Index (QHEI) Approach (Version 2.1). Ohio EPA. Northwest District Office.

Simon, T.P. and P.M. Stewart. 2006. Coastal Wetlands of the Laurentian Great Lakes: Health, Habitat, and Indicators. Authorhouse Press, Bloomington, IN. ISBN: 978-1-4259-2848-3.

USEPA. 1974. 316(a) Technical Guidance – Thermal Discharges. Water Planning Division, Office of Water and Hazardous Materials.

Figure 1. Sampling Location Map



Attachment 1

EA Electrofishing Field Manual

Prepared by:

EA Engineering, Science, & Technology, Inc.
444 Lake Cook Road, Suite 18
Deerfield, Illinois 60015

April 2002

1. INTRODUCTION

This field manual describes basic concepts and safety issues of electrofishing systems. The information in this document should also increase understanding of how the systems work and how to properly operate them to increase their effectiveness and reduce unnecessary harm to fish.

2. BASIC CONCEPTS

2.1 Electrofishing

In many cases, the most effective means of collecting fish for scientific purposes. Electrical current is placed in the water to immobilize fish, allowing them to be collected with dip-nets. It involves the use of either AC (alternating current) or DC (direct current) to immobilize fish for capture. These two types of current have very different effects on fish. The choice of current to use is dependent on the type of study being performed and the importance of returning healthy fish to the water.

2.2 AC & DC Current

AC current typically has the most violent effect on fish. Once in the electrical field a fish will immediately "take a posture transverse to the current in such a way as to receive a minimum of voltage" (Coffelt Electronics). This action is called **oscillotaxis**. Fish will be immobilized quickly and the effect will last longer than that of DC current. Great care must be taken in the collection of fish in this manner. If AC current is applied for too long of a period, the fish may not recover. Another drawback to this type of collection is that since fish usually become immobilized almost immediately when hit by the current, some may be missed because they are shocked while several feet below the surface and out of sight.

DC current, in most cases, will be the preferred method of collection. Fish react in three ways to DC current. First, they line up with the direction of the electrical current, then swim toward the anode (positive electrode). This reaction is called **galvanotaxis**. Finally, when fish near the anode they are stunned, roll belly up, and collection becomes possible. The effects of DC current do not last as long as of AC current. When the power is turned off the fish recover quickly. Mortality is far more limited than with the use of AC. This, along with the fact that fish actually swim to the anode, makes DC current the more effective means of electrofishing.

2.3 Control Box

AC or DC current can be selected with electrofishing control boxes. In addition to controlling the type of current, a control box allows adjustments to how the current acts. Most equipment will allow you to select for standard or pulsed output and to vary the pulse width and frequency of pulses, which allows for more efficient collections and limits the risk and stress to fish.

The control box also allows selection of voltage output. Depending on the electrofishing system used (i.e., Smith, Root or Coffelt), this selector should be positioned at the lowest possible setting that allows 5-10 amps to be obtained by adjusting the pulse width and rate or a minimum of 190 volts.

Pulsed output means that the electrical current going from the system into the water comes in pulses or waves. When the pulse rate is low and the width of the field is narrow, less current is required to collect fish. This results in less stress to fish. Since conductivity of water (the ease with which an electrical charge passes through it) varies, it is necessary to have the ability to adjust the pulse rate and width for optimum collection with minimum harm to the fish being collected.

2.4 Conductivity

Electrofishing works by passing electrical current through a fishes body causing the effects described above. Several factors affect the amount of current passing through the fish's body and thus, the effectiveness of electrofishing. If the conductivity of the fish's body is equal to or slightly above the conductivity of the surrounding water, the electricity will choose the path of least resistance and pass through the fish. The greater the conductivity of the fish's body in relation to the surrounding water, the greater the effect of the electricity on the fish. The conductivity of fish flesh differs among species. When shocking, you may observe catfish floating up as far as 50 ft. from the boat. At the same time, scaled fish may not succumb to the current until they actually pass within a few feet of the anode. Also, due to increased surface area, larger fish, particularly large and deep-bodied fish, tend to receive a larger charge of electricity than do smaller fish.

Another factor that influences the effectiveness of electroshocking is the conductivity of the water. Pure distilled water will actually act as an insulator in an electrical current. This is because there are few electrolytes or dissolved solids to conduct the electricity. It would take a great deal of current to pass through this type of water. Conversely, the water of a typical lake or river may be very high in dissolved solids. This water will readily conduct very low amounts of current. In all cases, the conductivity of the water must be equal to or below the conductivity of the fishes body for electrofishing to be effective. It is not effective to shock in salt water because it is an electrolyte solution. The conductivity of the water is so much higher than that of a fish that an electrical current will find that the path of least resistance is actually around the fish rather than through it.

Conductivity of the water being surveyed should always be checked before attempting electrofishing. If it is very low or extremely high, a different type of collection should be considered. When backpack or pram shocking small streams, it may actually be possible to increase the conductivity of the water by placing a block of salt upstream of the study area several hours before beginning your survey. This however, should only be considered in controlled conditions.

2.5 Types of Equipment

There are several types of electrofishing equipment available. EA typically uses boat, backpack or pram-type (tow barge) units. These units differ in the type of power source used and in their application.

Boat electrofishing is utilized where water depths and characteristics make maneuvering the boat possible. EA primarily uses this type of electroshocking in reservoirs and in navigable rivers. Boat electrofishing usually involves the use of a large generator (i.e., 5000 watt +) as an electrical power source. The generator sends electricity through a control box, which allows the operator to adjust the type of electrical current being placed in the water.

Both pram and backpack electrofishing are designed for use in areas where boat electrofishing may not be possible or practical. Backpack units consist of a power source (a small generator or battery) and a control box mounted on a backpack frame. A hand held positive electrode (anode) and trail behind negative electrode (cathode) are utilized by the operator to place electrical current in the water. The user is protected from the current by rubber waders and electrical gloves.

Pram shocking involves the use of a power source and electroshocking unit either placed on the bank or in a barge or small boat. Like backpack electrofishing, the operator utilizes a hand held anode and either a stationary or trail behind cathode to place current in the water. The methods differ in that the operator is not required to carry the power source. Cables with up to 100m of wire allow mobility over a large section of water.

In all types of electrofishing, current is passed through the water between a positive electrode (anode) and a negative electrode (cathode). EA typically uses a boom mounted anode and the boat hull as a cathode when boat electrofishing. You may however, see different arrangements. In backpack electrofishing the anode is a hand-held probe or dipnet and the cathode is a trail behind cable. In pram shocking, the cathode may be the hull of either the barge or boat carrying the equipment or a cable from a bank-mounted power source.

2.6 Equipment Operation

A typical boat shocking survey would be made up of two or three team members. The team leader or an experienced technician will operate the boat and shocking system while the other crewmember(s) will stand at a bow mounted railing and collect fish with properly insulated dip nets. Either the operator or the netter will operate a foot switch which will immediately cut the power output if released. This is a very important safety feature and no electroshocking boat should be operated without a safety switch.

Backpack and pram shocking are slightly more hazardous than boat shocking because of the user's position in the water with the electrical charge. Field training sessions should be completed with an experienced backpack or pram operator before attempting this technique. Basically, the system is a miniaturized version of the boat system. At least two operators are required. One person monitors equipment while the other handles the anode. The anode may have a dip-net attached to the end. The operator wades in an upstream direction through the water sweeping the anode 2-3 feet ahead. A thumb switch on the handle of the probe serves the same function as the foot switch on the boat. When a fish is shocked, the operator dips it up with the net, releases (turns off) the switches on the handle and places it in a bucket or live-well. When pram shocking, special attention should be paid by all crewmembers to the size of the electrical field. If the cathode is mounted on a barge, boat, or bank the electrical field will reach from that point to the anode held by the operator. When backpack shocking, this field is concentrated only around two probes.

3. SAFETY RULES

Safety is a matter that should be foremost on all crew members' minds when conducting electrofishing operations. The amount of current in the water may be in excess of 250 volts. The amount of amperage generated during typical shocking operations averages 8 amps. This is enough to **kill** you if you come in direct skin contact with an electrical source such as a cathode, anode, or improperly grounded boat or generator. This hazard is compounded by the fact that the boat and other equipment may be wet.

Always follow the manufacturer's instructions when installing or operating electrical equipment. It is each crew leader's responsibility to familiarize crew members with the equipment and how to operate it. Furthermore, it is the responsibility of each crew member to assure that others are following proper procedure. If you are asked to do something that you feel is improper or unsafe, you have the authority to refuse. Don't depend on someone else to look out for you. Look out for yourself.

Despite all of this, electroshocking surveys can be conducted in a safe manner. All that is required is proper attention to detail and the use of the safety equipment provided to you.

Here are some common sense rules that **must** be followed by all crew members at all times:

1. Wear rubber gloves when operating electroshocking equipment.
2. Never touch a loose wire or make an adjustment while unit is in operation.
3. Always use safety switches.
4. Never over-extend yourself when netting fish.
5. Communicate hazards to boat operator. The operator has a limited view in front of the boat because of the position of the netters. Don't assume he/she sees what you see. If noise level restricts normal conversation, establish hand signals.
6. Never place your hand in the water.
7. Keep boat deck as dry and clear of obstacles as possible.
8. Look up from the water from time to time to assure that overhanging branches or other items don't pose a risk.
9. Wear hearing protection.
10. Maintain the equipment through routine maintenance checks. If repairs are needed, get them fixed immediately. Don't wait for the next person to do it.
11. A PFD must be worn by all crew members during operations